errors to be found in meteorological registers. Each error creates considerable confusion; it throws doubt on the observations accurately made at neighbouring places; and that doubt cannot be removed except by the continuity of the records at those places. This continuity is unattainable unless the weather happens to be uniform over a wide district, or unless observations are made at many more places than would be needed, if reliance could be placed upon the accuracy of the observers. Another advantage of self-recording instruments is that their records are independent of particular scales. Their notation is in lines and curves that can be measured with equal facility according to any desired scale. The thermometer lines could be measured at pleasure according to Fahrenheit's scale, as used in England; to the Centigrade, as in France; or to Reaumur's, as in Germany. The barometer lines could be measured with equal ease in English inches, in millimetres, or in Paris feet. For the various reasons we have mentioned, self-recording instruments are of eminent local and international utility. The establishment of a series of them in England would confer a wide benefit. They would give precision and fulness to the charts of our own weather; they would set an example that foreign governments would soon follow; and they would afford material in a very acceptable form to meteorologists at home and abroad for the discussion of the weather of Europe at large."

II. "On the Action of Compasses in Iron Ships." By Mr. John Lilley. Communicated by Sir W. Snow Harris, F.R.S. Received February 9, 1866.

Although many ably-written papers upon this subject have at various times appeared, none of them seem to be of that simple practical character as to supersede the necessity of any further investigation of the subject, or deter the author from submitting to the Royal Society the results of many years' practical experience in the construction of the mariner's compass, and its adjustment in iron ships. These results are given with a view to advance our knowledge of this important and great practical scientific question, and to add still more to the security of life and property. In the present day, when iron shipbuilding is so widely extending, it is presumed that the most humble offering tending to place the directive action of the compass beyond the reach of disturbing magnetic forces may not be unacceptable.

It is unnecessary here to enter into a mathematical investigation of the properties or magnetic condition of iron ships, this part of the subject having been already fully treated and developed by many learned men. The author rather proposes to confine himself to the consideration of the probable causes of the disasters so frequently attendant on the navigation of iron and other ships, through defective compass guidance; such disasters, according to the author's experience, may be traced, in a large majority of cases, to one or other of the following causes:—

1. The improper construction and position of the steering binnacle and compass.
2. The too frequent habit of placing all reliance upon the steering binnacle compass.
3. Allowing the compasses to be too long in use without due examination.
4. The improper manner in which the compasses have been adjusted.

1. The construction of the compass is at all times a matter of great importance, but when applied to the case of an *iron* ship its value is increased tenfold; it is most essential that the compass should be of the best attainable description, and so constructed that its centre and pivot should be subject to the smallest possible amount of friction, in order that the needles may be entirely free to follow the directive force of the earth, and have at the same time great retentive power. Some years since the author observed, when adjusting an iron steamer's compass furnished by him with very powerful needles, discarded from some previous experiments in magnetism, and which were only 4 inches in length, that more than usually satisfactory results were obtained; the deviations were of a smaller value, and far more uniform than when using needles of greater length. He has since adopted the practice of employing needles not exceeding 6 inches in length, even for cards of the largest diameter.

The position of the compass is also important; it is an objectionable practice of too frequent occurrence, even with the ordinary plane spindle and barrel, to place the binnacle near the steering-wheel; with the screw apparatus, arms, and levers the practice becomes extremely dangerous, the whole mass, from the process of manufacture, being found highly magnetic. The idea, however, prevails that all this is a matter of indifference, since the counteracting magnets are supposed to neutralize all magnetic disturbance. The reverse, however, is the case; many instances have come under the author's notice practically in which errors have arisen solely from this cause, but which ceased to exist on the removal of the binnacle to a distance of 4 feet from the spindle, or twice the original distance.

It would be far better, in all cases, if the steering-wheel could be placed before the mizen-mast of ships, instead of abaft and close to the stern, as is generally the case; compasses would invariably act better and be subject to smaller changes.

2. It is too frequently the practice to place exclusive reliance upon the *steering*-compass; this may be attended with less trouble to the navigator, but is, as regards the safety of the ship, very perilous. As ships are now fitted, the steering-compass is placed very near the stern; and since in iron ships the magnetic forces are generally concentrated at the two ends of the vessel, it must be obvious that it is placed at that spot where the greatest variations may be expected. Every iron ship should be furnished with a properly constructed standard binnacle not less than 5 feet high above the deck, suitably placed, and containing a compass fitted in the most con-

venient manner for taking observations without the aid of compensating magnets. By this compass *alone* should the ship be *navigated*; the steering-compass is simply the helmsman's guide. Many iron ships have been fitted with two navigating binnacles, the one for steering, and the other at the fore part of the poop, both furnished with compensating magnets, and obviously both subject to the same changes incident to the change of hemisphere; cases of ships thus fitted have come under the author's notice, in which many providential escapes from wreck have occurred on the return passage from India; in one particular instance, land was made on the coast of Ireland when the commander imagined he was entering the channel, an error that could not have arisen had the ship been furnished with an uncompensated standard compass instead of a compensated compass.

In the uncompensated compass, the changes of deviation are far less than would be found in a compensated compass placed not more than 2 feet above iron beams. Very full directions on this subject will be found in the valuable work of the late Capt. E. J. Johnson, R.N., and it is much to be regretted that this work is not more studied by commanders and officers of iron ships.

3. Frequent disasters have been found to occur in consequence of allowing the compass to be too long in use without due examination, more particularly in steam-vessels going short voyages; the author is led to this conclusion from the fact of having readjusted iron vessels' compasses stated to be largely in error, but subsequently found, on swinging the ship, to have a comparatively small error, the supposed error being referable to a defective centre and pivot in the compass itself, which prevented the needle from reaching its meridional position. In such cases an error of 8° or 10° has been often observed; the importance of such an error in narrow channels is too obvious to require comment.

There are valuable and simple appliances which to a very great extent remove this difficulty, and which are comparatively inexpensive; it is to be much regretted that a great indifference to the state of vessels' compasses exists in the minds of those under whose care the compasses are often placed, and who, it might be expected, would from experience have been more sensitively alive to the absolute necessity of keeping the compasses, as far as possible, in a state of efficiency. If a compass looks clean upon its surface, it is believed to be in a perfect state, although it may have been stowed away with the card upon the pivot without any protection, thus interfering with the most important of its working parts; as a consequence, the card, when required for use, will be sluggish upon its pivot, and a false indication of the direction of the vessel's head is an unavoidable result.

4. A defective adjustment of the compass is again a vital source of error. This mainly depends, 1, on the locality in which the vessel is swung, which is too often a dock, where other iron vessels lie in dangerous proximity; 2, a want of due precaution on the part of the adjuster, in the

place selected for the shore-compass. This is a matter of great importance, far more than is often supposed. As the corrections made on board necessarily depend upon the bearings given from the shore, if these are faulty, the ship's compass cannot be otherwise than incorrect.

The author has more than once seen a shore-compass within a very short distance of an iron shed. The prevailing practice of swinging a ship in the short space of two hours is also very objectionable; it is utterly impossible to regulate compensating magnets, and to make the requisite observations for the use of soft iron, in so short a time; it does not allow the vessel to be stayed upon the several points for a sufficient scrutiny of the compasses, sometimes three in number, and the results are too often merely guessed at, and thus all the advantages of that admirable system of adjusting iron vessels' compasses, introduced by the Astronomer Royal, and which are invaluable to our coasting and short voyage vessels, are, to a great extent, negatived.

London is unfortunately very badly provided with the means of adjusting the compasses of iron vessels, and, as their number is so much increasing, this subject is daily becoming more important; the docks are crowded, and it is by mere chance that in the Victoria Dock, the only available dock at our command, a sufficiently clear space is to be met with. Greenhithe remains as the last resource in this dilemma; here moorings have been laid down by the City authorities for the use of merchant-vessels, but they are too near the edge of the tide. A very strong down current exists; the entire space of slack water in the Reach is occupied by *two* sets of moorings for the use of the Royal Navy. It would be a very great boon if one of these sets of moorings were allowed to be used by the merchant service, when not required for Her Majesty's Navy. It rarely happens that both sets of moorings are at the same time required for use. As the swinging a ship, moreover, at Greenhithe is entirely dependent upon the tide, it must be commenced with the flood, added to which, the operation is often much impeded by the wind, so that in the winter months, when the days are short, and the seven hours of ebb occur during nearly the whole of daylight, much serious delay is the result; the author has often occupied three days in adjusting a ship's compasses.

The construction of a dock for this purpose would be very desirable; the expense may be urged against the proposal; but surely in London, one of the greatest mercantile cities in Europe, such an undertaking should be regarded as a national matter, and it is believed that shipowners would not object to pay a small rate of charge for the use of such a dock which might render it self-supporting.

An opportunity for constructing such a dock may possibly arise in the formation of the new docks at Dagenham, where the expense of an entrance would be saved by simply making a basin from the dock large enough to swing a ship 400 feet in length round a dolphin placed in the centre, and well supplied with mooring-posts for ropes to be made fast to, and a suitable

spot for the shore observer—of course removed from all possibility of attraction by iron in the immediate vicinity; such basin to be kept exclusively for this purpose, and known as "The Ship-swinging," or "The Compass-adjusting" Dock.

With the view of deducing a practical result from what has been advanced in the foregoing remarks, the author would most strongly urge the necessity of some official inspection of iron vessels with reference to their compass-fittings. A code of rules and instructions might be laid down for this purpose; this would be essential in the cases of *new* ships; *old* ships should be examined at stated times, and certificates of compass adjustment be recognized by the appointed officer solely from those who can furnish evidence of having been properly instructed by competent persons, so that such an important work should not be allowed to be taken up and carried on by any amateur as his fancy may dictate.

It may be a question how far a Government inspection would be cordially received by shipowners or public companies; it might by some be regarded as an undue interference; the Government also might be indisposed to incur the cost of an extra office, with all its details; it might be more properly thought a matter for the consideration of Lloyd's. It is a question assuredly in which underwriters are largely and personally interested, and they already hold arbitrary powers as concerns the construction of the hull of a ship. The simple question of the compass as a means of safety is comparatively disregarded.

The above suggestions are offered with great deference, and the author would rather leave the subject in the hands of those more conversant with legislation than himself; but he cannot refrain from repeating that the results of his own practical experience (which has been of no small amount) convince him that an official supervision of the compass-fittings of iron ships has become, from various causes, absolutely requisite.

III. "On the Tidal Currents on the West Coast of Scotland." By Archibald Smith, M.A., F.R.S. Received March 1, 1866.

The tidal currents on that part of the west coast of Scotland which is comprised between the Mull of Cantyre and the Island of Mull run in general with great velocity. Their velocity, direction, and the time of their change, or of slack water, are therefore matters of great importance to navigators. On the other hand, the rise and fall of the tide is so small, and the depth of water in the channels and the harbours so considerable, that the times of high and low water are of comparatively small importance.

While the laws of the currents are thus of more importance than the laws of the rise and fall of the tide, they are also much more simple. The times of high and low water are very different at different parts of the